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ANALYSIS OF THE PROPERTIES OF CONCRETE BY ADDING POLYPROPYLENE FIBERS

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Abstract: **In comparison to conventional construction materials i.e. wood, steel etc. the polymeric materials reinforced with synthetic fibers such as glass, carbon etc. does have blessing of high stiffness and strength to weight ratio. As there is no rose without thorns, similarly widespread use of synthetic fiber reinforced polymer composite is confined by theirhigh initial cost, their use in non-efficient structural forms and most importantly their adverse environmental impact. These days increase the interest in using natural fibers as reinforcement in concrete and minimize Conventional synthetic fibers around surrounding the researchers have focused on using natural fibers reinforced with synthetic polymerfibers. The present work includes analysis of properties of concrete with partial replacementof fine aggregates with hemp & polypropylene fibers and study of compressive and split tensile strength of the fiber reinforced concrete tensile strength of the fiber reinforced concrete**

The addition of polypropylene fiber increase the compressive the addition of strength initially & then start decreasing with increase in fiber quantities. The addition of polypropylene fibers effect on the split tensile strength has shown a gradual increase with the addition of fiber.

I. INTRODUCTION

The use of fibers in building materials to improve their behavior is an old and intuitive concept. Examples include adding straw fibers to sun-dried mud bricks (adobe) and asbestos fibers to pottery to create a composite with a better performance. Recently research and design of fiber reinforced concrete began to increase in importance in the 1970s, and since those days various types of fibers have been developed such as steel fiber, Synthetic Fibers (Hemp, Nylon and Polyester), glass fibers, etc.

Natural fibers, however, display large variations in fiber properties from plant to plant, such as strength, stiffness, fiber length and cross sectional area. These variations can ultimately lead to difficulties in composite design and performance predictions. Natural fibers are also thermally unstable compared to most synthetic fibers, and are limited to processing and working temperatures of 200°C. Another major drawback when using natural fibers is the fact that they are hydrophilic (absorb water) and polar in nature whereas common thermoplastic matrices such as polypropylene are hydrophobic (do not absorb water) and non-polar. Natural fibers used in thermoplastic matrices are therefore dimensionally unstable and display poor fiber-matrix interfacial bonding, which results in poor composite mechanical properties. It is therefore necessary to modify the fibers, the matrix or both to produce a composite with improved mechanical properties

CONCRETE

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape. It is readily available in urban areas at relatively low cost. Concrete is strong under compression yet weak under tension and a relatively brittle material. As such, a form of reinforcement is needed. The most common type of concrete reinforcement is via steel bars.

The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance and long service life. It also has a few disadvantages like poor tensile strength, and formwork requirement.

Types of Fibers in Concrete

- Carbon Fibers
- Steel Fibers
- Glass Fibers
- Synthetic Fibers
- Natural Fibers

POLYPROPYLENE FIBERS IN CONCRETE

For the last 30 years, steel fibers have been used as secondary reinforcement in fiber concrete and for the past 15 years, special glass fibers with much improved alkali- resistance have been used as reinforcement for neat cement. However, both of these fibers are rather costly, and this has limited the use of these types of fiber reinforced materials. Polypropylene fiber is a plastic fiber.

Table 1: Properties of Fibers

Fiber Type	Diameter 0.001 in.	Specific Gravity	Young's Modulus Ksi	Tensile Strength Ksi	Strain Failure, %
Steel					
High Tensile	4.0-40.0	7.80	29,000	50-250	3.5
Stainless	0.4-13.0	7.80	23,200	300	3.0
Glass					
E-glass	0.4	2.50	10,440	500	4.8
Alkali resistant	0.5	2.70	11,600	360	3.6
Polymeric					
Polypropylene					
Monofilament	4.0-8.0	0.90	725	65	18
Fibrillated	20.0-160.0	0.90	500	80-110	8
Polyethylene	1.0-40.0	0.96	725-25,000	29-435	3-80
Polyester	0.4-3.0	1.38	1450-2500	80-170	10-50
Acrylic	0.2-0.7	1.18	2,600	30-145	28-50
Aramid					
Kevlar 29	0.47	1.44	9,000	525	3.6
Kevlar 49	0.49	1.44	17,000	525	2.5
Asbestos					
Crocidolite	0.004-0.8	3.40	28,400	29-260	2-3
Chrysotile	0.0008-1.2	2.60	23,800	500	2-3
Carbon					
I (high modulus)	0.30	1.90	55,100	260	0.5-0.7
II(high Strength)	0.35	1.90	33,400	380	1.0-1.5
Natural					
Wood cellulose	0.8-4.7	1.50	1450-5800	44-131	-
Sisal	<8.0	-	1890-3770	41-82	3-5
Coir (coconut)	4.0-16.0	1.12-1.15	2760-3770	17-29	10-25
Bamboo	2.0-16.0	1.50	4790-5800	51-39	-
Jute	4.0-8.0	1.02-1.04	3770-4640	36-51	1.5-1.9
Akwara	40.0-160.0	0.96	76-464	-	-
Elephant grass	17.0	-	716	26	3.6

Its raw material, derived from the monomeric C3H6 is a pure hydrocarbon similar to paraffin wax. This type of fiber was suggested as an admixture to concrete in 1965 by Goldfein for the construction of blast-resistant building for the U.S. Corps of Engineers. Ready mixed concrete containing polypropylene fibers can be placed using conventional methods. To ensure maximum performance all entrapped air must be expelled from the concrete to achieve optimum density.

Properties of Polypropylene Fibers

1. A sterically regular atomic arrangement in the polymer molecule and high crystallinity.
2. A high melting point (165°C) and ability to be used at temperatures over 100°c short periods
3. Chemical inertness making the fibers resistant to most chemicals
4. The stretching process in manufacturing results in a parallel orientation of the poly chain molecules in the fiber.
5. The orientation leaves the film weak in the lateral direction, which facilitates fibrillation.

The modulus of elasticity of the polypropylene fibers ranges between 1 GPa (143 Ksi) and &GPa (14 X 10 Ksi) depending on the strain rate and it is much lower than that of an average concrete 30 GPa (4.29 x 10^3Ksi).

Mixing Polypropylene Fibers with Concrete

Different types of mixers have been used in practice, some requiring adjustment to the existing equipment, some none at all. Additional equipment has been installed in some plants to chop and to facilitate proportioning the fibers. Tumbler mixers disperse the fibers without complications. This also applies to ready mix Lorries which either carry a pre-weighed bag of fibers, or receive the fibers on site from stock held there. On arrival on site, the fibers are dropped in the drum which is kept rotating for three to five minutes before placing Pan mixers, either slow or high-speed, sometimes needed some adjustment to deal successfully with fibers which have different dimensions from the normal aggregate sizes The blades inside pan mixers may need to be set at different angles if the fibers are collected on the edges or in poorly streamlined comers. However, many pan mixers have been found in practice to accept mixes with chopped polypropylene fibers without alterations, for concreting, dry mixing of cement, sand, and fibers has proved possible without special precautions. In this operation, water is added at the gun orifices and the fan which below the dry mix through the hose worked without too much stoppage. If the continuous twine or filament arrives on spools at the precast factory, it is cut to staple fiber by specially developed equipment. The cutter is placed in line with other batching machinery, and can also combine its task with accurate proportioning

Effect of Polypropylene Fibers on Workability

Workability has been defined differently by several authorities Basically it is considered to be that property of plastic concrete which indicates its ability to be mixed handled, transported and, most importantly, placed with a minimum loss of homogeneity. The workability of a mix is measured by standardized test, the slump test, the V-B consist meter test and the Compacting factor. The slump is a common fast & economical test, but unfortunately, it is not a good indicator of relative workability. For instance, the slump of a mix of plain concrete with a W/C ratio of 0.5 was found to be 88mm. but when polypropylene fiber volume of 0.50% was added to the mix, 'the slump decreased to 12 mm, although the mix flows satisfactorily when kept moving, responds well to vibration. However, Slump can be used as an indicator of relative uniformity for fiber reinforced concrete, but results must be evaluated with caution.

The effect of increasing polypropylene fiber volume on the workability of concrete should be studied by a test hat measure the mobility or fluidity of the mix. The method requires a slump cone (ASIM C-143), a standard one-cubic-foot yield bucket (ASTM C-29), and an internal vibrator. The vibrator is started, inserted into the center if the cone, and allowed to fall freely to the yield bucket bottom approximately a few seconds required for total immersion of the vibrator, The vibrator is held vertically with the end of the vibrator just resting on the bottom of the bucket. The time from initial immersion of the vibrator to when the slump mold is empty is recorded as the test time. This test primarily measures the mobility of the mix and takes into account the effects of aggregate size, shape, and gradation; air content, surface friction of the fibers. This test also eliminates the fiber orientation that occurs when rodding slump cone tests In general, when polypropylene fibers are added to concrete, the workability would decrease to some extent. This reduction in workability depends on the fiber volume, fiber length, and geometry of the fiber plus the other factors which affect the workability of the concrete.

II. LITERATURE REVIEW

It outlines some of the recent reports published in literature on natural fiber reinforced composites and with chemical treatments to enhance their different mechanical properties.

Bharath.S et. al.,2017 Present experimental study was conducted to determine the optimum dosage of polypropylene and steel fibers. The mechanical properties of fiber reinforced concrete were investigated by including polypropylene and steel fibers. The standard cube test specimen, cylinder test specimen and prism test specimen were casted, cured and tested for 7, 14, & 28 days as per Indian standard guidelines. In this experimental study it was found that the optimum dosage of Poly Propylene Fiber was 0.05% by volume of concrete and that of Steel Fiber was 0.75% by volume of concrete. Both PFRC and SFRC exhibited convincing behavior compared to HPC (conventional concrete) at the specified optimum dosage. Also the test results showed that use of steel fiber reinforced concrete improves compressive strength and tensile strength compared to conventional concrete (HPC).

Salahaldein Alsadey et.al.,2016 To study the effect of polypropylene fiber on compressive strength of concrete, the experimentation is conducted in the laboratory. Based on the experimentation conducted, on the cubes with different percentage of polypropylene fiber the following some conclusions were drawn. 1. The reduction of slump is noticed with increase in polypropylene fiber content, especially beyond 2 % dosage, the mix become fibrous which results in difficulty in handling. 2. The compressive strength tests reveal that, the strengths were increased proportionately with the increase in volume ratios of polypropylene fiber with reference to the control mix without fiber. 3. The percentage increase of compressive strength of polypropylene fiber concrete mixes compared to the mix without fiber is observed from 4 to 12 %. 4. The samples with polypropylene fiber content of 2 % showed optimum results in comparison with other samples in this study.

K.Anbuvelanet. al.,2014 For M1 Grade of Concrete Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete improves the characteristic no. of blows to a maximum extent of 15.38% - 45.85% for first crack and 14.95% - 45.98% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete shows improvement in no. of blows by 71.19% , 198.11% and 105.61% , 207.55% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete. For M2 Grade of Concrete Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete improves the characteristic no. of blows to a maximum extent of 9.61% - 25.17% for first crack and 8.21% - 22.44% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete shows improvement in no. of blows by 144.60% and 166.82% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete. For M3 Grade of Concrete Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete improves the characteristic no. of blows to a maximum extent of 1.30% - 97.06% for first crack and 4.51% - 103.79% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fiber in plain concrete shows improvement in no. of blows by 3036.92% - 7366.15% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete natural fiber reinforced polymer composites (NFC) for automotive industry. The use of NFC can solve environmental waste problem up to a large extent. Through various comparisons and research he found that date palm fiber (DPF) is the best selected fiber among all other types. DPF is the best regarding specific Young's modulus to cost ratio criterion. Technical properties and performance, environmental, economic and societal aspects strongly contribute toward adopting DPF into the automotive sector to improve its sustainability and productivity. The adoption of DPF has a significant environmental influence throughout achieving an efficient sustainable waste management practice.

Kabir et. al, 2013 noticed the effect of different chemical treatment on hemp fibers. Hemp fibers were treated with alkali acetyl and silane chemicals. The chemical and thermal effects of these chemicals on the fibers were examined by using scanning electron microscope (SEM). Fourier transform infrared (FTIR) spectroscopy. Thermal gravimetric analysis (TGA) the experiments showed the hemi cellulose, thermal stability and hydrophilic nature of the fibers for different chemical treatments.

III. OBJECTIVES OF PAPER

The objectives of thesis are as follows:

1. The philosophical objective of the thesis is to contribute to the knowledge of the properties of fiber reinforced concrete (FRC) helping to extend the use of the material to structural design.
2. Study of the effect of using Polypropylene fiber on concrete compressive

3. Assessment of the effect of hemp fiber reinforcement in minimizing plastic and drying shrinkage cracks of the concrete.

4. Improve the overall durability and long-term performance of concrete structures.

IV. RESEARCH METHODLOGY

Material Used For Research

- Polypropylene Fibers
- Cement
- Fine Aggregates
- Coarse Aggregates
- Water

Mix Proportions

The experimental program consists of investigating compressive strength concrete modified by the use of Polypropylene fiber. Mix design used in the test is M 20 and water cement ratio is kept constant throughout i.e. 0.5. Concrete has then further modified by using glass fiber in four proportions of 0.5%,0.25, 1%, 1.5% and 2%. 4:5.2 Mixing Process

The batching procedure was as follows:

1) Add coarse, fine aggregate and sand than mixing for about 2-3 minutes.

2) Add cement than mixing for about 1-2 minutes.

3) Add approximately two-thirds of water slowly and mix for 2-3 minutes.

4) Add fiber with water than mixing for 2-3 minutes.

Specimen Details

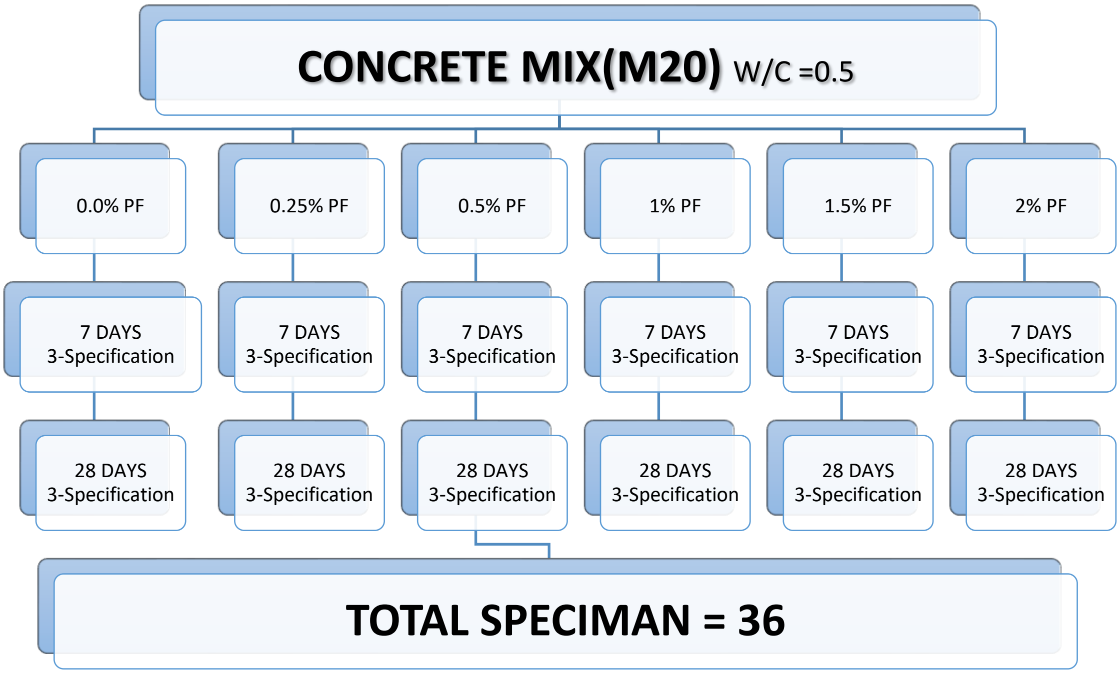


Fig. 1: Flow chart of the Experimental Program

Table 2: Number of cubes casted

Mix	**Cubes without PF***	**Cubes with 0.25% PF***	**Cubes with 0.5% PF***	**Cubes with 1.00% PF***	**Cubes with 1.5% PF***	**Cubes with 2% PF***
M20	3	3	3	3	3	3

Following mixes were prepared and are detailed below:

150x150x150 mm sized cube specimens will be prepared for Compressive Strength. The materials required were weighed according to the mix proportion. Compressive Strength will be tested confirming IS: 516-1959 after 7 days and 28 days of curing.

Mixing

After weighing accurately cement, sand and coarse aggregates, these have been mixed dry to get uniform color. Fiber have been mixed by sprinkling them with the hand while mixing in such manner the fiber are distributed uniformly throughout. Water has been added to mix and proper mixing is ensured. Balling and lump formation, if found anywhere has been loosened to achieve a homogeneous mix.

Casting of Specimens

Fig 2: Preparation of Moulds& Casting of Specimens

Compaction

For compacting fiber reinforced concrete usual methods of mechanical vibrations such as obtained in a needle or table vibrator, can be used. Needle vibration however, is not preferred with higher volume contents of fiber, as holes left by needle may remain unfilled due to interlocking effect of the fiber. Table vibrator is most suitable as it gives advantages of fiber acquiring a tendency to align them in a plane perpendicular to the direction of vibration. This results in random planer orientation. A fiber mix generally requires somewhat greater vibration to move the mix and consolidate it into the moulds. The compaction of the specimens has been done on a platform vibrating table.

Fig 3: Preparation of Compaction

Curing

Identification marks have been engraved into the specimen after 4 -5 hours of casting. They are allowed to set in the moulds for 24 hours after which they have been taken out of the moulds and immersed in fresh water for curing for a specified period of time. The specimens have been then removed from water and stored in room till their time of testing.

TESTING OF SPECIMENS

In the present study, specimens have been tested under the 3000kN capacity automatic compression testing machine (ACTM). This machine fulfils the entire requirement for compression testing as per IS: 516-1959. Specimens stored for curing have been tested immediately on removal from water, while they are in wet condition. Surface water and grit has been wiped off the specimens. The bearing surfaces of the testing machine also have been wiped clean and any loose sand and other material is removed.

Compressive strength test

Cube specimens have been placed centrally in the machine in such a manner that the load is applied to opposite sides of cubes as cast that is not to top and bottom. The load is applied in a continuous and uniform fashion without shock with the help of computer attached machine at a pace rate of approximately 5. 0 kN/s automatically. The compressive strength is obtained by the formula as given below

Ϭ =P/A

Where P = load at which the cube specimen fails in KN

A = cross sectional area of cube is 150*150 mm^2

Compressive Strength Testing According To ASTM C 39.

1. 7 — Day Specimens Age
2. 28 — Day Specimens Age

V. RESULTS AND DISCUSSION

This point includes the test results in which Polypropylene fiber are used in the different ratios. It is done to obtain the desired compressive strength. Mix design used in the test is M20 and water cement ratio is kept constant throughout i.e. 0.5. In this work, compressive strength properties of concrete modified by addition of Polypropylene fiber are studied to investigate whether the strength can be increased or decreased by addition of small amount of these fiber. As to investigate the strength Polypropylene fiber of 6 mm length are added in the mix in different ratios. The effect of Polypropylene fiber on compressive strength of concrete are discussed in detail below:

SLUMP TEST

Mould in the shape of a truncated cone with base diameter of 200 mm and internal top diameter of 100 mm. The height of cone was 300 mm. The mixes are designed to maintain the slump near to 50 mm.

Fig 4: Slump Flow Test

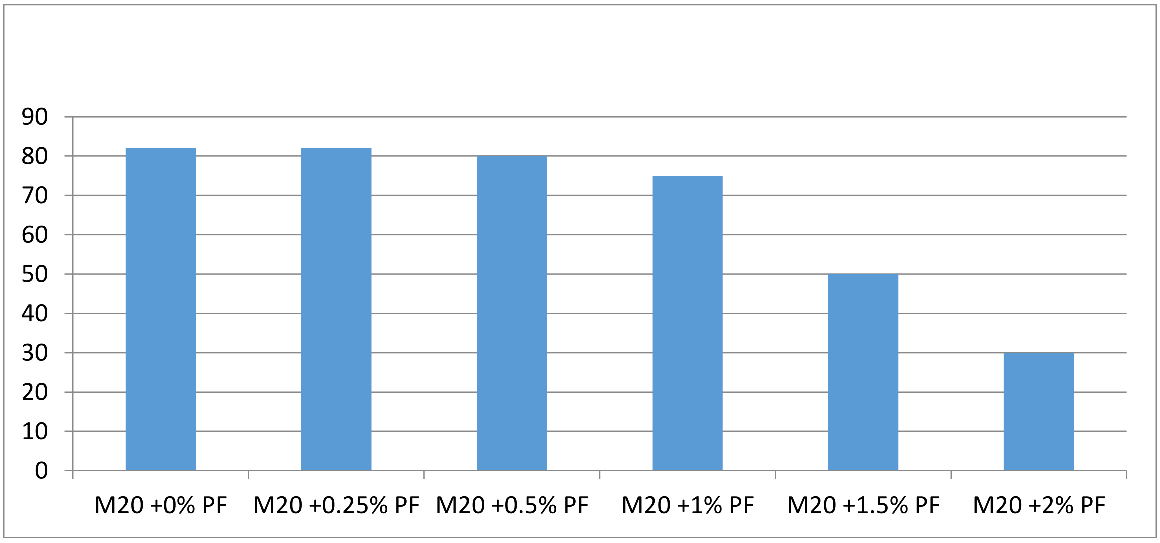
Table 3: Recommended slumps as per IS : 456-2000

Slump value	**Degree of workability**
Less than 25	Very low
25 to 50	Low
50 to 100	Medium
100 to 150	High

To study the workability of concrete with maximum ratio of glass fibre, slump test has been carried out and results have been shown in the table:

Table 4: Degree of Workability of M20

Type of mix	Slump value in mm	Degree of workability	Increase or decrease w.r.t. normal
M20 +0% PF*	82	Medium	-----------
M20 +0.25% PF*	82	Medium	
M20+ 0.5% PF*	80	Medium	Decrease
M20 +1% PF*	75	Medium	Decrease
M20 + 1.5% PF*	50	Low	Decrease
M20 + 2% PF*	30	Low	Decrease



PF* Polypropylene Fiber

Fig 5: Degree of Workability of M20

Effect of Polypropylene Fiber on Compressive Strength:

Fig 6: Checking of Compressive Strength

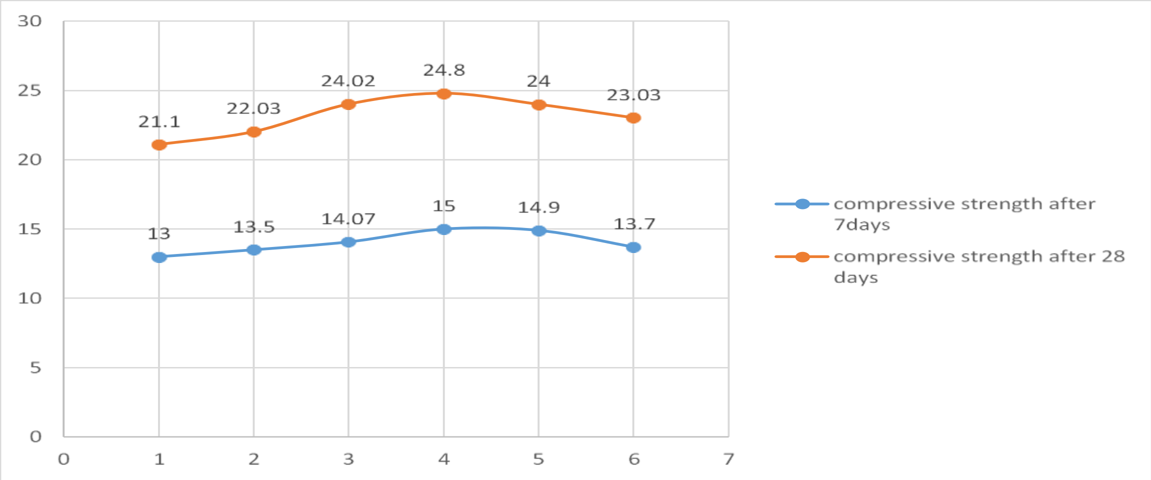


Fig 7: Variations in M20 after 7 and 28 days

Table 5: Compressive Strength Variation in 7 and 28 days for M20

S.No.	**M20** +Polypropylene fiber	**Compressive strength (N/mm^2)**							
		7 Days				**28 Days**			
		I	**II**	**III**	**Average Value**	**I**	**II**	**III**	**Average Value**
1	0%	12	12.5	14	12.83	21.16	21.50	21.26	21.30
2	0.25%	12.5	13	13.5	13	21.86	21.93	22.15	21.98
3	0.5%	13.45	14.1	14.25	13.93	23.67	23.88	23.8	23.78
4	1%	14.87	15	15.4	15.09	24.25	24.92	24.82	24.66
5	1.5%	14.25	13.92	14.1	14.09	23.86	23.93	24.12	23.97
6	2%	13.75	13.35	13.18	13.42	22.84	22.92	23.14	22.96

* Average of 3 Specimens

VI. CONCLUSION

- The addition of polypropylene fibers effect on the compressive strength has increasing by 6.1% with (0.25%) of fiber than start decreases by with increases the fiber quantities.
- High quantities of fiber produced concrete with poor workability and segregation, higher entrapped air and lower unit weight.
- A significant effect on the mode and mechanism of failure of concrete cube in a compressivetesting with (FRC).The fiber concrete fails in a more ductile mode.

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